Electric Grid Transactions Modelling with DER-CAM

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Partners: CEPRI, Massachusetts Institute of Technology (MIT), EPRI, Metropolitan Washington Council of Governments, Brookhaven National Laboratory, Fort Hunter Liggett, TriTechnic, MIT Lincoln Laboratory, University of New Mexico, Public Service New Mexico, Universidad Pontificia Comillas – IIT, Xcogen Energy LLC, CSIRO, NEC

DER-CAM DECISION SUPPORT TOOL FOR DECENTRALIZED ENERGY SYSTEMS
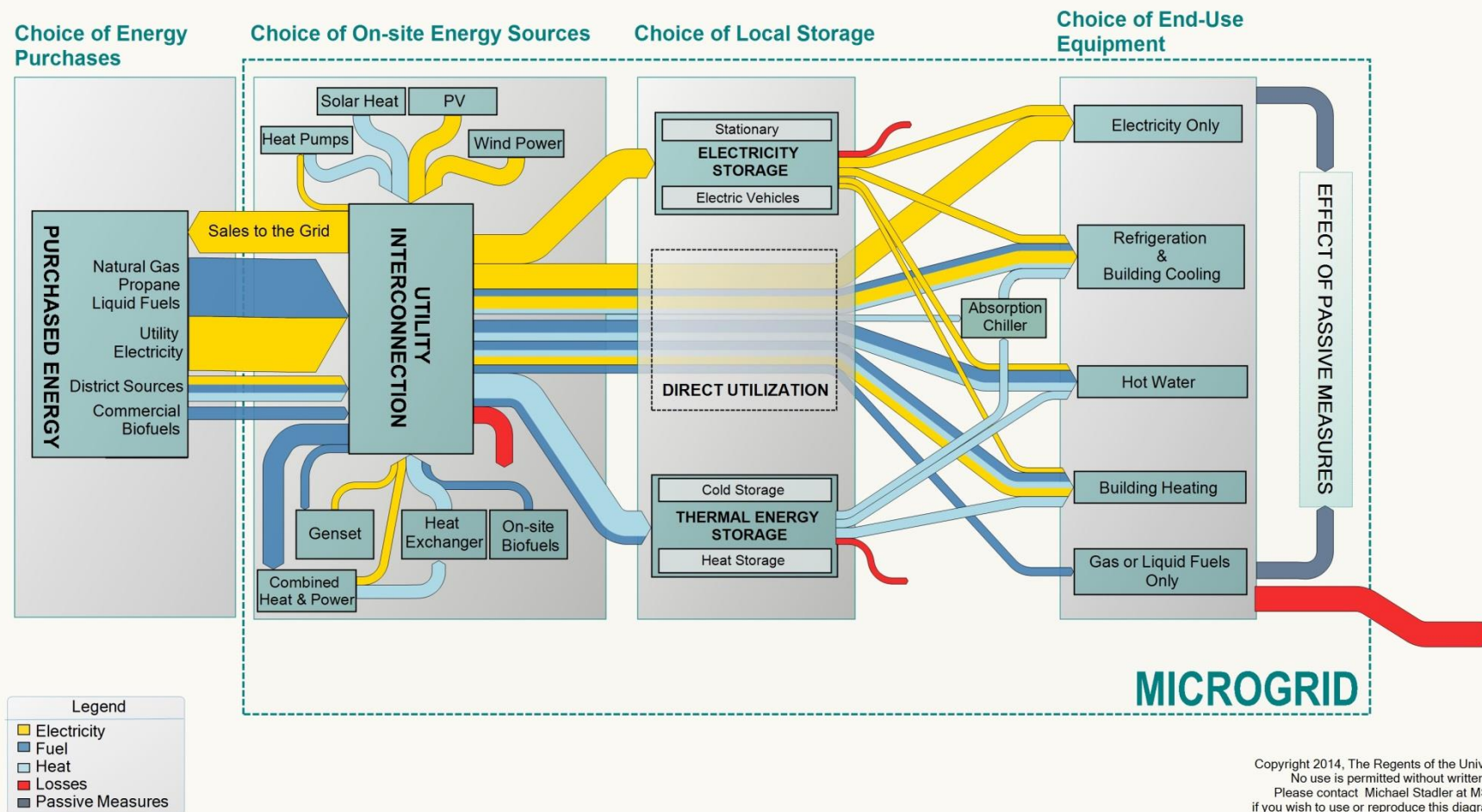ANALYTICS | PLANNING | OPERATIONS

U.S. DEPARTMENT OF **ENERGY**

openADR™

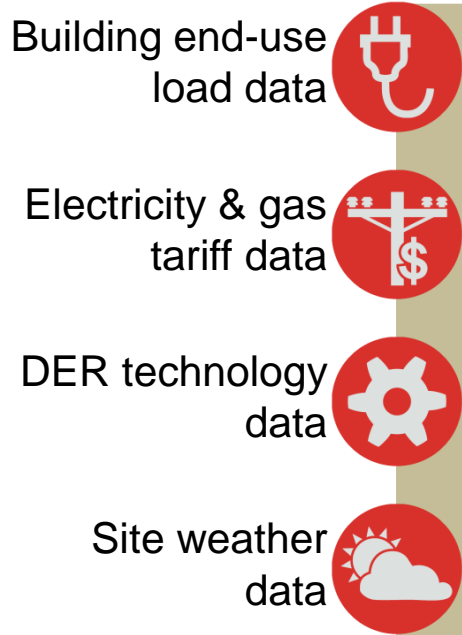BERKELEY LAB

Global Model for Microgrids and DER in Buildings

Microgrid Architecture and Decision Making with DER-CAM

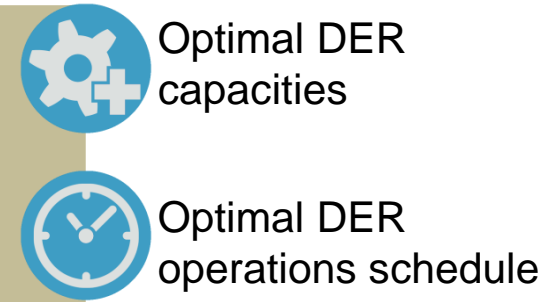# Distributed Energy Resources Customer Adoption Model (DER-CAM)

- is a deterministic and stochastic Mixed Integer Linear Program (MILP), written in the General Algebraic Modeling System (GAMS®)

- started as a building CHP optimization tool 13 years ago

- supported by the U.S. DOE, OE, DoD, CEC, private industry

- two main objective functions:
  - cost minimization
  - CO_2 minimization

- other objectives are possible, as well as multi-objective subject to microgrid/building constraints and energy balance

- produces optimal investment and dispatch results for biogas/diesel/natural gas CHP, fuel cells, ICE, micro-turbines, gas-turbines; PV, solar thermal, hot and cold water storage, batteries, heat pumps, absorption chiller, EV, passive measures (insulation, window changes, etc..)
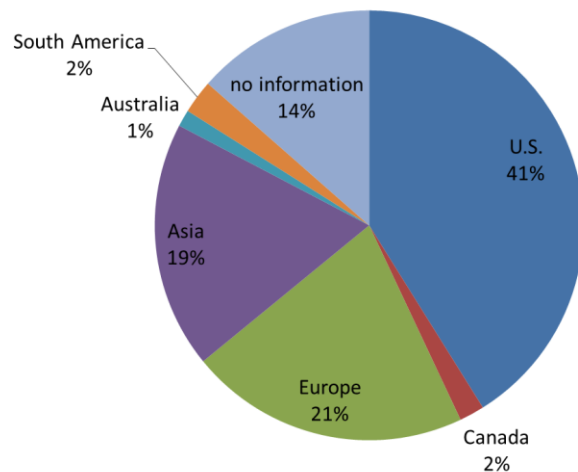
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Inputs:

Building end-use load data

Electricity & gas tariff data

DER technology data

Site weather data

DER-CAM

Objectives:

Minimize total cost

Minimize CO_2 emissions

Outputs:

Optimal DER capacities

Optimal DER operations schedule

- **Investment & Planning:** determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs → Microgrid Design Tool

- **Operations:** determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather and tariffs → Controller

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DER-CAM Users

- DER-CAM has been proven by journal papers, reports, and field test (200 hits on Google)

- DER-CAM has been used as microgrid design tool by private entities outside of LBNL

- 700 worldwide users (11% in China, one DER-CAM version has a Chinese interface)

Web DER-CAM Users (WebOpt) by Region (43 Different Countries Total)

- South America 2%
- Australia 1%
- no information 14%
- U.S. 41%
- Asia 19%
- Europe 21%
- Canada 2%

Web DER-CAM users (WebOpt) by Business Type
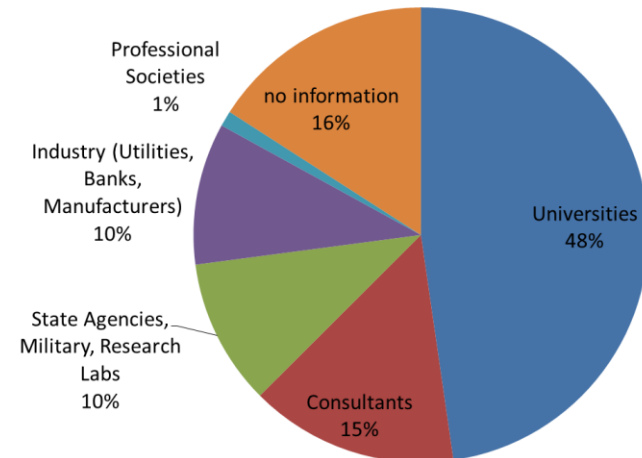
- Professional Societies 1%
- no information 16%
- Industry (Utilities, Banks, Manufacturers) 10%
- Universities 48%
- State Agencies, Military, Research Labs 10%
- Consultants 15%

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Our Partners and DER-CAM Licensees

Application

Distributed Energy Systems Integration and Demand Optimization for Autonomous Operations and Electric Grid Transactions

What is OpenADR?

- OpenADR is standardized communication data model for sending and receiving DR signals from a utility or independent system operator to electric customers

- provides non-proprietary, open standardized DR interface

- allows electricity providers to communicate DR signals to customers

- uses common XML language and existing communications such as Internet

Utility or ISO — Operators — Information System — API — Internet — Demand Response Automation Server — Internet — API — Aggregated Loads — Site A — Site B — Site C — Site D — Site E

API = Standardized Application Programming Interface

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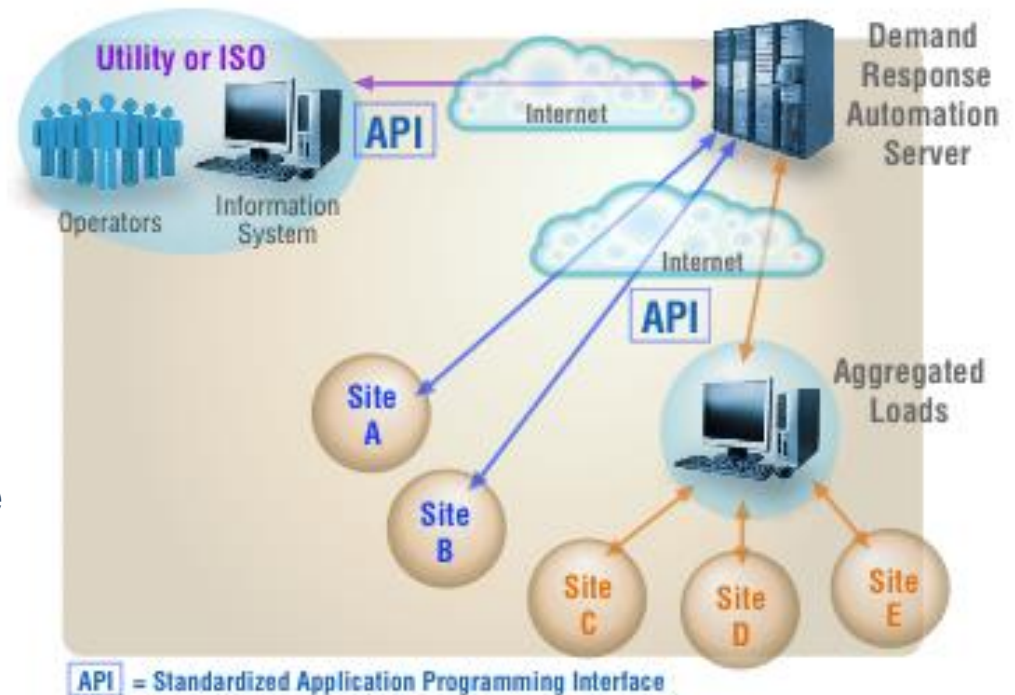
Existing Grid Transaction Operation Scenario, and New Dynamic Operation Scheme for Distributed Energy Resources (DER) as Storage, Combined heat and Power, etc.
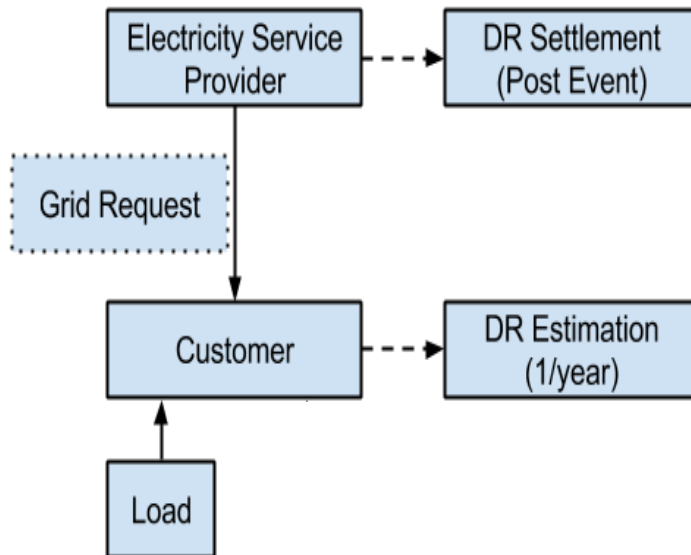
Old
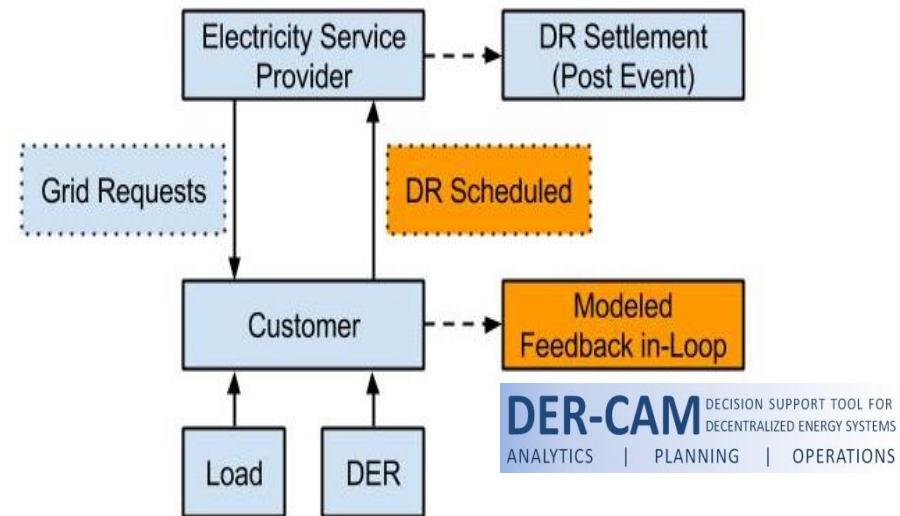
New

Closed-Loop/Model in the Loop Interactions between a DR Service Provider and a DER-CAM-Enabled Customer
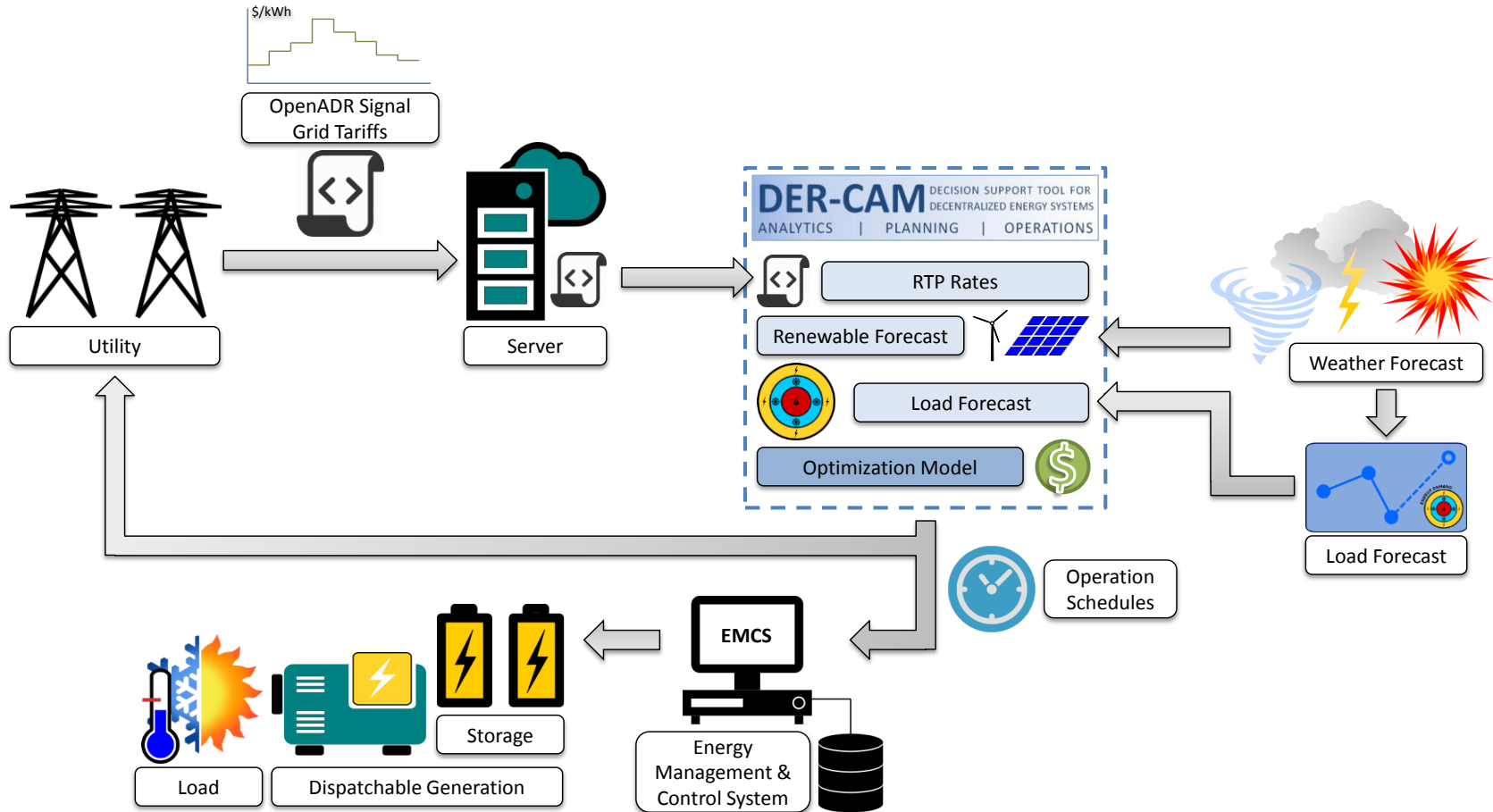
DR shedding Potential from DRQAT to DER-CAM
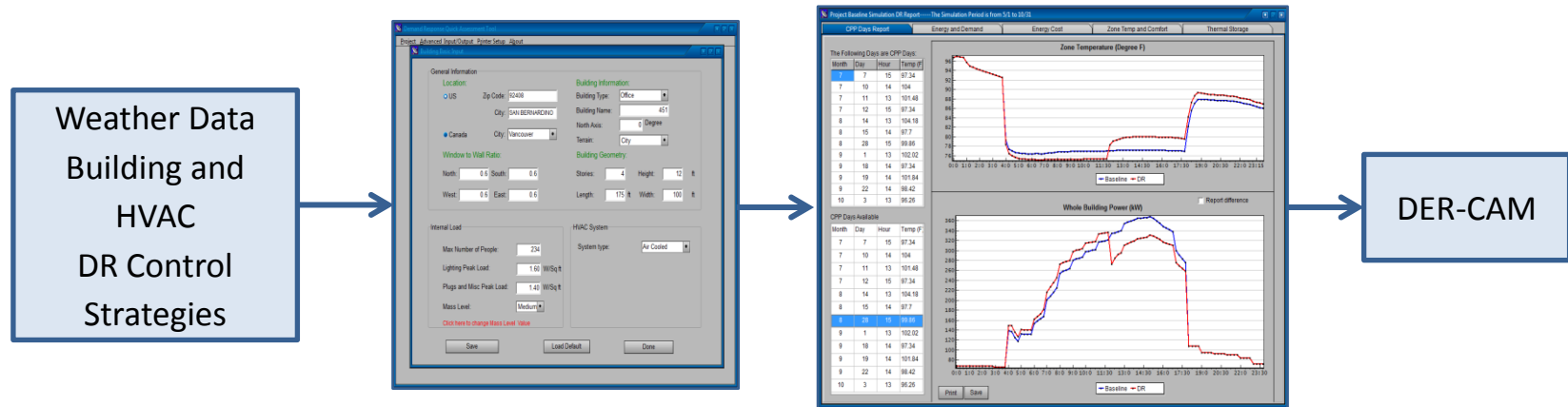
OpenADR Communication Architecture and DER-CAM Integration

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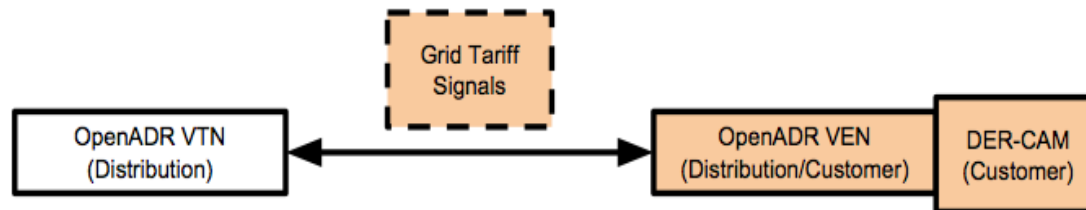
Test Case for a Big Campus in California

- peak electrical load of 2.4 MW

- 2 MW of PV

- 1 MWh of Li-ion battery (2 units of 500 kWh / 625 kW)

- several backup diesel generators, adding up to 4 MW

- Real Time Pricing Program (RTP)

- DR service provider (utility) uploads the RTP hourly prices for the next day to the OpenADR server, RTP prices are determined by supply and demand

- In our case RTP prices depend on temperature (HVAC)
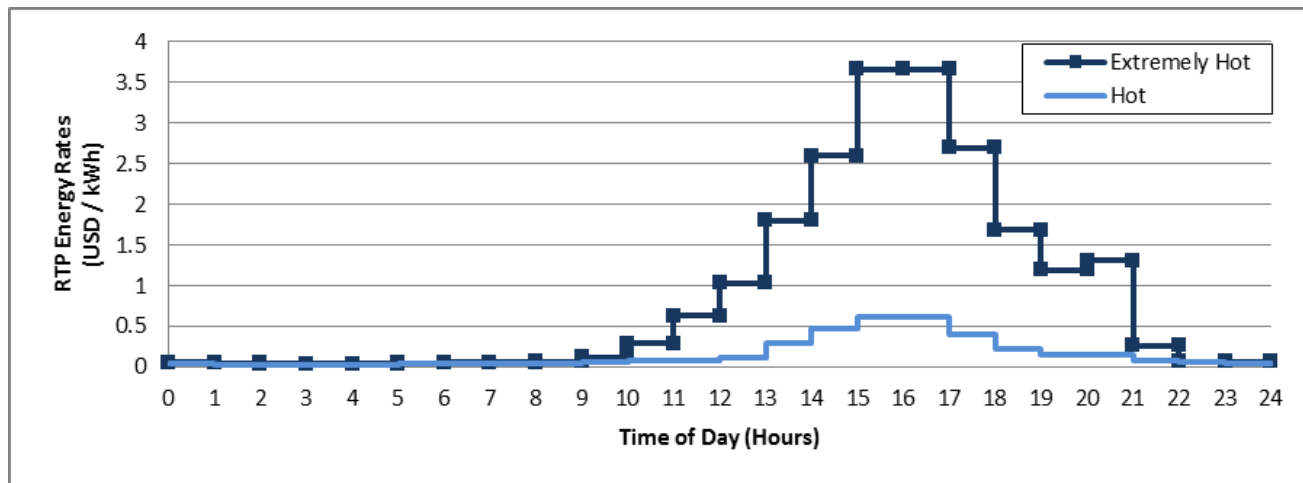
hot: 85°F–90°F
very hot: 91°F–94°F
extremely hot: >=95°F

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openADR™

Results with Daily Energy Cost Limit for Site: 1.5 x Baseline Costs

	Hot	Very Hot	Ex. Hot	Hot	Very Hot	Ex. Hot	Hot	Very Hot	Ex. Hot
	Batt. Cap. 1000 kWh			Batt. Cap. 2000 kWh			Batt. Cap. 5000 kWh		
■ Total Daily Electricity Purchase (kWh)	13300	12100	9480	13000	12400	9200	12400	12352	10600
■ Elec. Purchase b/w 2 and 6 pm (kWh)	3137	1210	903	2858	959	154	2140	460	0
■ Load Reduction (kWh)	0	1260	3840	0	763	3840	0	0	1710
■ RTP Energy Cost (USD)	2950	4430	6670	2750	4130	4510	2280	3420	3420

Results with Daily Energy Cost Limit for Site: 1.5 x Baseline Costs, 5MWh Battery

No energy from utility during critical noon hours

more energy from battery

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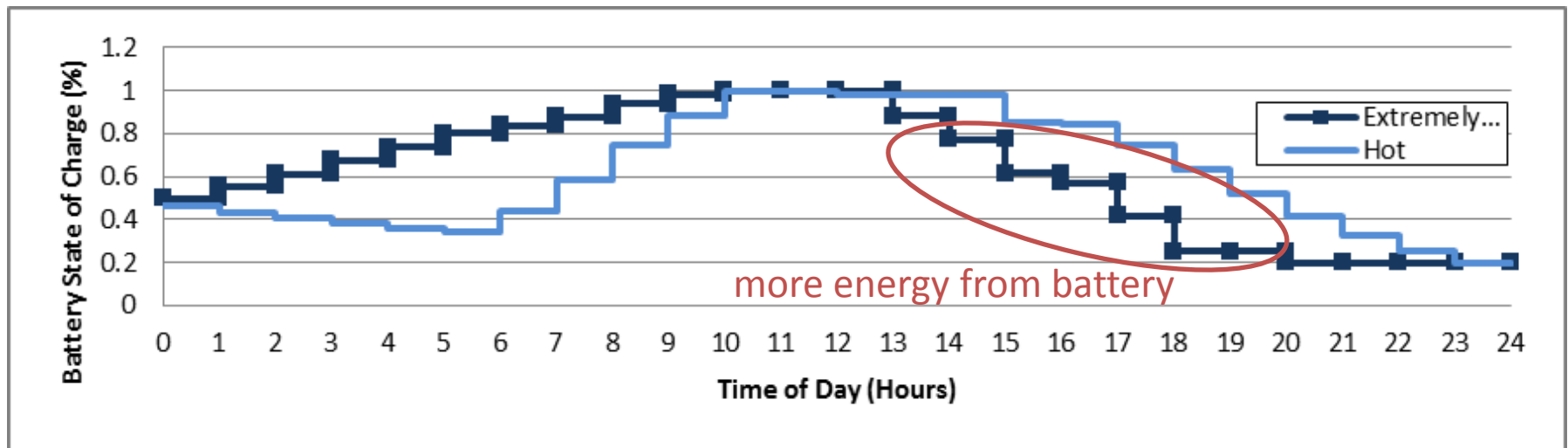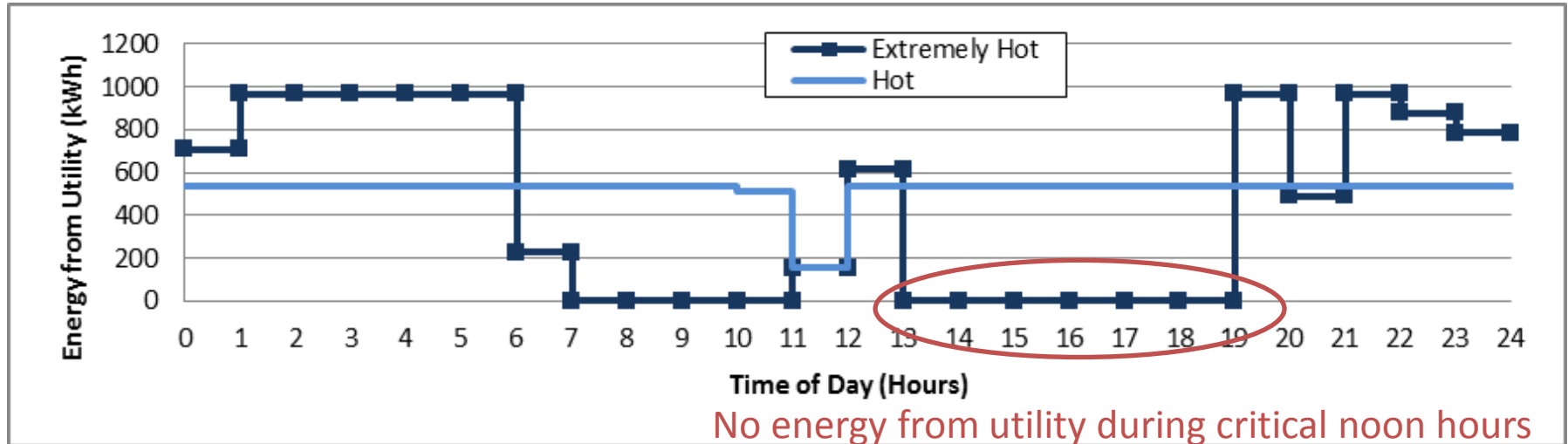
Questions and comments are very welcome!
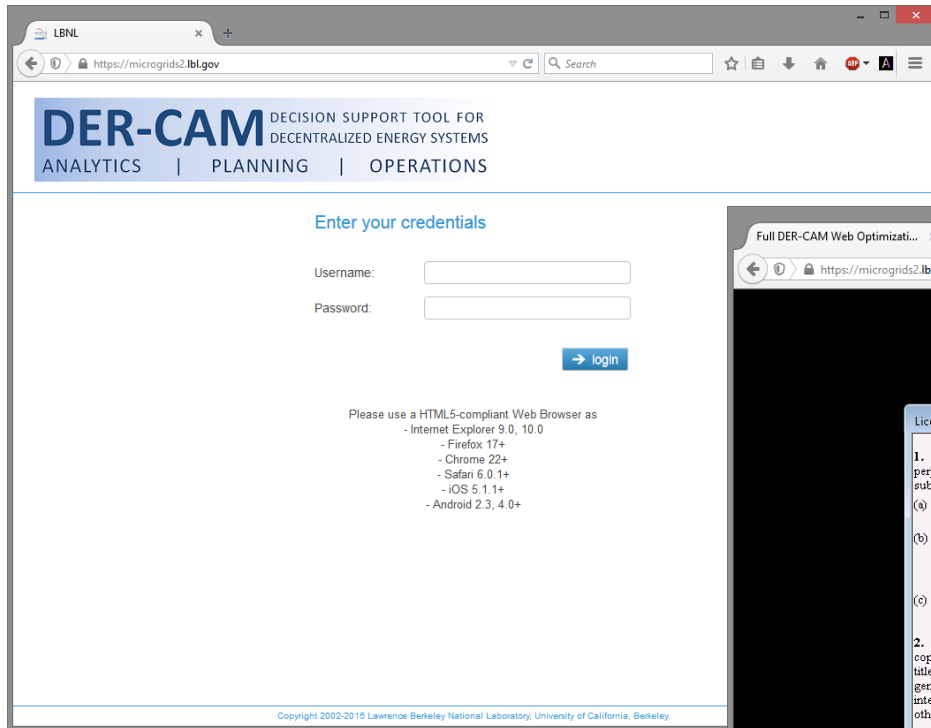
Backup Slides

Investment and Planning DER-CAM

Login Screen

Advanced user login allows access to customized versions

New Project

Model Overview

standard window structure: **1**: Table navigation ; **2**: Data input ; **3**: Help
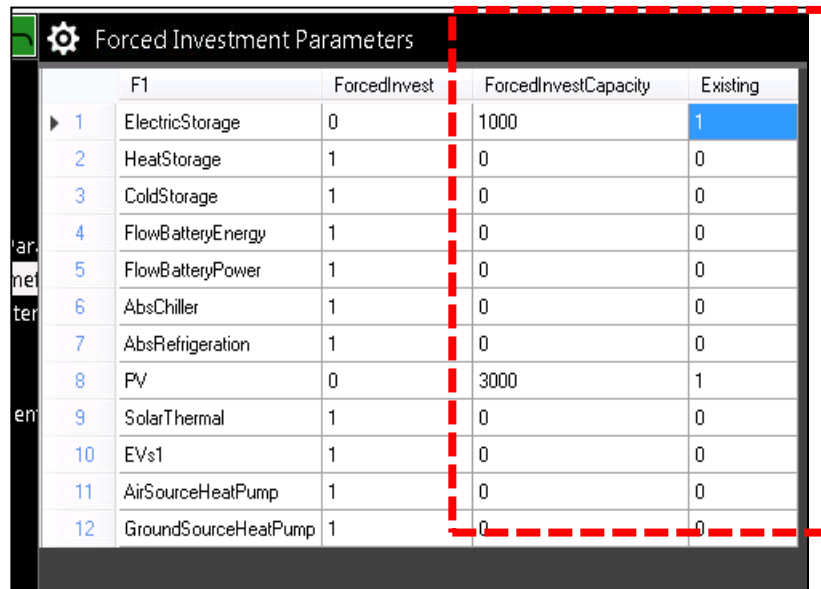
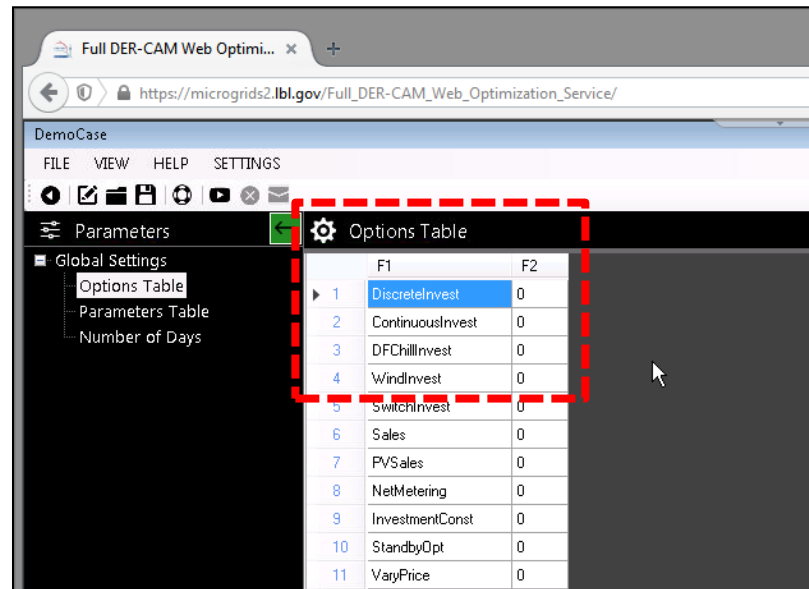## *Building a Model: Reference Case vs. Investment Case*

DER-CAM finds the optimal investment solution that satisfies several groups of constrains:
- energy balance (electric, heating, cooling, etc.)
- physical (rated capacity, conversion efficiency, available roof space, etc.)
- economic (discount rate, maximum payback period)

in order to satisfy the economic constrains, a **reference cost** must be obtained and the reference cost can be estimated by running DER-CAM with the <u>existing infrastructure</u>

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Building a Model: Reference Case vs. Investment Case

the total annual energy costs obtained in the reference case will then be used in the investment scenarios to allow estimating savings and return period of new investments

the results obtained in any run are stored on the server and can be sent via e-mail

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Building a Model: Investment Case

after updating the reference costs and CO_2 emissions, an investment case can be performed
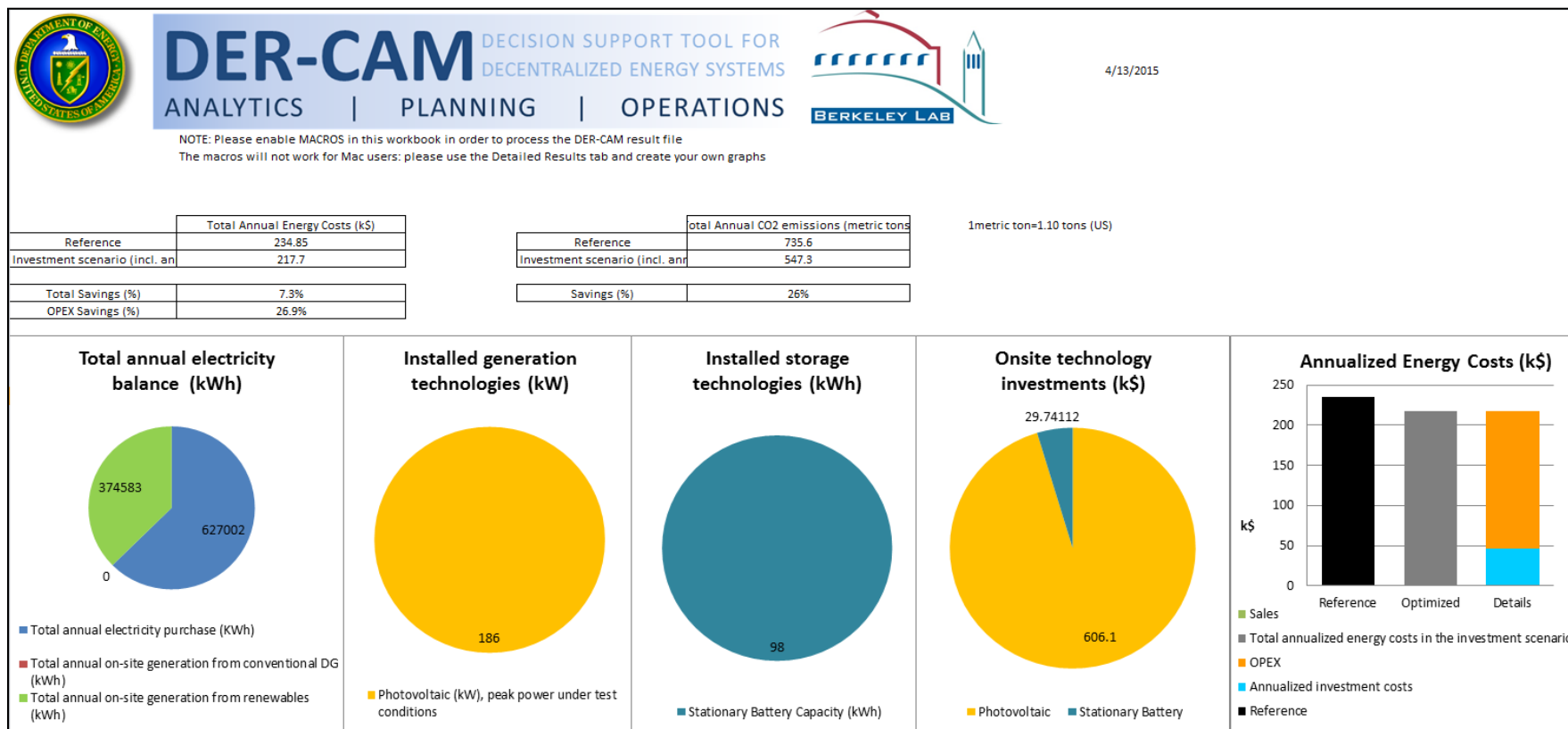
Building a Model: Results

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Building a Model: Results

Yearly investments and operational costs (k$)

Details for Electricity (July-week)